REPRINT OF THE "IDEA OF A NEW ANATOMY OF THE BRAIN; submitted for the observations of his friends; by CHARLES BELL, F.R.S.E."

To which are added selections from LETTERS written by the Author of the ESSAY to his brother, Professor George Joseph Bell, between the years 1807 and 1821.

AT the meeting of the British Medical Association, held at Oxford last August, a copy, in manuscript, of the Essay, of which the title is given above, was brought under the notice of the Physiological Section. Some members then expressed an opinion that, owing to the well-known important character of the work, as containing the first announcement of the principles on which the modern improvements in our knowledge of the nervous system are founded, and the difficulty of procuring original copies on account of their scarceness, it was desirable that a reprint should be made. When that wish was communicated to the widow of Sir Charles Bell, she promptly consented to its being reprinted in this Journal.

It was at the same time intimated to the Editors that, as the main object of reproducing the Essay was to throw light on the development in the author's mind of his views on the distinct functions of the nerves, certain unpublished documents, which would add to the interest of the reprint, would be placed at their disposal. These, were selected passages from letters which the author wrote before composing the Essay, and when the "*Idea* of the New Anatomy of the Brain," had just flashed on his mind.

The letters were written to his brother George Joseph Bell; who afterwards attained high eminence at the Scotch bar. Of him it was said, by Lord Cockburn, in the "Memorials of his Times," that he was "Our greatest modern institutional writer." In another part, speaking of the most elaborate of his works, the "Mercantile Commentaries," he thus expresses himself: "Bell's is the greatest work on Scotch jurisprudence that has ever appeared since the publication of Lord Stairs' 'Institute.' Its authority has helped to decide probably eighty out of every hundred mercantile questions that have been settled since it began to illuminate our courts; and it has done, and will do, more for the fame of the law of Scotland in foreign

countries, than has been done by all our law-books put together." To this brother, only a few years older, Charles was from earliest youth warmly attached: and when separated, by the latter going to London, they kept up a constant brotherly intercourse by letters. Fortunately those written by Charles were preserved; and, at the death of George Joseph, which occurred after his brother's decease, the letters, from which extracts are about to be given, came into the possession of his daughter, Miss Bell. These were collected and arranged by her, with the hope that, together with other materials, they might form a biographical memoir of both brothers. Her death, however, impeded the publication; and those passages of the correspondence only which relate to the early researches in the nervous system by Sir Charles are now offered to the profession; suffering, as it may be understood, in no slight degree, from being torn from their contexts.

When Charles Bell, slenderly provided with money, and having few friends, moved to the metropolis, it was an act of hardihood to commence the career of Lecturer alone; the teachers in the several great medical schools being then Cline and Cooper in the Borough, Abernethy at St Bartholomew's, Sir Everard Home and Wilson in the West. It is not without interest, that, in the very year (1807) in which he founded his school, and delivered lectures to a class of three pupils, he began to look upon the Nervous System as a fertile field for cultivation.

The following are extracts from the letters up to the date of the printing of the Essay :—

21*st May*, 1807.—"I am casting about for a subject to make something new of. I have been thinking of the Brain—of Mind—of Madness. Could I not put this subject in the form of queries, as to the best way of prosecuting it, to be laid before Stewart[1], or Jeffrey[2], &c.? I would not publish any thing but in Papers for these many years."

26*th Nov.* 1807.—"I have done a more interesting *Nova Anatomia Cerebri* than it is possible to conceive. I lectured it yesterday. I prosecuted it last night till one o'clock. And I am sure that it will be well received."

31*st Nov.* 1807.—"My surgical books and lectures you will soon see eclipsed by my character as an anatomist and physiologist. I really think this new view of the Anatomy of the Brain will strike more than the discovery of the lymphatics being absorbents."

[1] Professor Dugald Stewart of Edinburgh.
[2] Lord Jeffrey.

Dec. 5th, 1807.—"My New Anatomy of the Brain occupies my head almost entirely. I hinted to you that I was 'burning,' or, on the eve of a grand discovery. I consider the organs of the outward senses as forming a distinct class of nerves from the others. I take five tubercles within the brain as the internal senses. I trace the nerves of the nose, eye, ear, and tongue to these. Here I see established connection—there the great mass of the brain receives processes from the central tubercles. Again, the great masses of the cerebrum send down processes or crura, which give off all the common nerves of voluntary motion, &c. I establish thus a kind of circulation, as it were. In this inquiry I describe many new connections—the whole opens up a new and simple light, and the whole accords with the phenomena, with the pathology, and is supported by interesting views. My object is not to publish this, but to lecture it, to lecture it to my friends, to lecture it to Sir Joseph Banks' coterie of old women, to make the town ring with it, as it is really the only new thing that has appeared in anatomy since the days of Hunter; and, if I make it out, as interesting as the circulation, or the doctrine of absorption. But I must still have time: now is the end of a week and I will be at it again."

March 28th, 1808.—"I have been thinking of having a room five or six miles from town, and there pursuing my physiology of the Brain—that which is to make me, I am convinced."

8th July, 1808.—"I have your very kind letter beside me. The motives and views you give me are very consolatory. I am, or have been since you left me, a very idle fellow—taking extracts from Dante, and making appropriate sketches. But last night I sat late with my notes on the Brain; and I will send you my Introduction—which is a view of the whole System. It is this I would print; but the description of the Brain I will reserve for more labour of succeeding winters.

"I wish you would take a book of Anatomy, be it the *Encyclopedia*, or anything, to understand the received account; that you may know my *merits*—how different the view I take. I confess I like it the more I consider it: but this is common, you will say, in all hobbies."

15th July (the letter continued).—"The night ended with a guinea; and the morning began with it.

"I have said that I have completed my view of the Brain. But it is only the Introduction to the strict anatomy, giving a view of my system. For I find that it embraces the whole Nervous System. As soon as John (Shaw) has transcribed it, I'll send it down to you. I expect you will correct it, and have it transcribed, and then give it to Jeffrey and Playfair[1]; as I will here to Brougham[2] and some others.

"I think that to the profession at large it will prove most

[1] Professor Playfair of Edinburgh.
[2] Lord Brougham.

acceptable. And while some will adopt it I trust, the most captious will say it is ingenious. But read, and give me your opinion. Explain that I wish to have read before the Royal Society a series of Papers—this being the first; the second being more strictly anatomical; and the third being the subject treated pathologically. I'll write to Jeffrey about it. Or if it does not seem good to us to have it read before the Society, then perhaps to have it printed: or first read here, and then printed. But I wish to have it in some way agitated before the winter."

16*th July* (*continuation of the same letter*).—"I am writing my 'Dissections[1],' and, I trust, making it very good. And I have thought much, though I have done little in writing my 'Brain.' In truth, the writing must be short, and yet embracing much. I am delighted with it more and more; and I must very soon send you a précis of it, that we may talk it over in our letters."

5*th Aug.* 1808.—"I am much pleased with what you say of my MS. of the Brain. I hope Jeffrey will like it. How can you be anxious for its originality? Did I not tell you to read, before you got it? To tell you the truth, you cannot be more pleased with it than I am. I am sure that I am correct; and I think there will be a great proportion who will, as you say, acknowledge that it is ingenious, when they mean to say it is not true.

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"I am really engaged so that my 'Surgery[2]' goes on slowly. You ask what Campbell[3] is doing. Between ourselves, he is palsied with fear. He dare not publish; and he has never gone further than you saw. If this delay were a test of genius I must be a mighty great one too:...Could you not get Dugald Stewart or Playfair to look at my MS. of the Brain?...(*Continuation of same letter*). I have just received your packet; and it is a little perplexing. I cannot distinguish Jeffrey from you. You have concealed from me the general impression upon Jeffrey. It is not meant to explain the anatomy of the Brain; but to state, to those who are supposed to know it, the ground and outline of a train of observations; to follow in Papers on the Anatomy and Pathology of the Brain; and to establish my claim to these discoveries, if I may yet term them so.

"Yet there may be good reason why I should address myself to the ignorant; though I know it will be construed into conceit and parade. But I will set earnestly to work to do it. Jeffrey is quite an unaccountable person; but I wish you had either told me his opinion, if he gave it, or given the MS. to somebody who would speak. For it is very unpleasant to be so long in the dark, writing to please oneself, without knowing how my system touches others. You seemed much pleased. And when you examine a subject I take

[1] Duodecimo edition.
[2] Operative surgery.
[3] The Poet.

you for a better judge than Jeffrey. The points really the most interesting and novel in the 'Anatomy of Expression' never touched him; but, as now, he took to the manufacture of the thing only[1]. His observations, as you say, are admirable; and it will be my business to profit by them. To tell you the truth, what you got was my first penning of the subject; and I could never set about altering its arrangement. Jeffrey, I find, thinks that not important which is the very basis of the whole; he would like a beautiful Essay better than the most striking fact. Your questions on the margin show how far I have mistaken in not stating the present system of anatomy. But still, I say, if I do it in that way, instead of a short statement of what is new, you will find a long essay and controversy. A wise man, they say, should hear everything; but act according to his own sentiments. I'll try to do this."

4th Dec. 1809.—"I think I told you I was kept busy by having all my usual time of relaxation occupied by revising books for reprinting. But last night I took a long pull at the subject of my most anxious contemplation—the Brain; and so heated myself with it, that at half-past two I had no more disposition to sleep than now. All my patients are warlike—eight officers[2]...I shall be very bloody in this Brain of mine. I must make experiments; and that is what I hate to do."

26th Dec. 1809.—"Speaking of books, could you get a little tiny book printed for me, of the smallest 12mo.? For I must send you down the MS. of the Brain again, stated shortly, for my friends."

After anxiously attending John Shaw for scarlet fever, he himself had an abscess in one of the tonsils, from which he was for some time in much danger. Both repaired to Hampstead for change of air; and there he wrote:—

10th Jan. 1810.—"Precaution more than necessity takes me to the country; for before I lecture again I have much anatomical work to do; and that I won't do till quite in strength."

13th Jan. (the letter continued).—"I have even in my present sickness been intent on the idea of some great work. Sometimes I think of finishing my anatomy of the muscles; or of painting in great style. I have had thoughts of entering on a great work of Pathology. The Brain I wish still to resume, after giving out a short account of my view, as taken from my lectures. It was this I proposed to you to print in Edinburgh. In short, this inertia of the body has stirred up ambitious projects."

The extract which follows has a special interest, from marking

[1] Alluding to the review of that work in the *Edinburgh Review*, No. XVII. 1806.

[2] At that time he had published his "Dissertation on gun-shot wounds; founded principally on observations upon the wounded received into Haslar and York hospitals, from Corunna."

the date of the first series of experiments on the roots of the spinal nerves:—

2d March, 1810.—"I write to tell you that I really think I am going to establish my Anatomy of the Brain on facts the most important that have been discovered in the history of the science.

"You recollect that I have entertained the idea that the parts of the Brain were distinct in function; and that the cerebrum was in a particular manner the organ of mind; and this from other circumstances than what I am now to detail to you.

"It occurred to me that, as there were four grand divisions of the Brain, so were their four divisions of the spinal marrow: first, a lateral division, then a division into the back and forepart. Next, it occurred to me that all the spinal nerves had within the sheath of the spinal marrow two roots, one from the back part, another from before. Whenever this occurred to me I thought that I had obtained a method of inquiring into the function of the parts of the Brain.

"Exp. I. I opened the spine, and pricked and injured the posterior filaments of the nerves; no motion of the muscles followed. I then touched the anterior division; immediately the parts were convulsed.

"Exp. II. I now destroyed the posterior part of the spinal marrow by the point of a needle; no convulsive movement followed. I injured the anterior part, and the animal was convulsed.

"It is almost superfluous to say that the part of the spinal marrow having sensibility is what comes from the cerebrum; the posterior and insensible part belongs to the cerebellum.

"Taking these facts as they stand, is it not most curious that there should be thus established a distinction in the parts of a *nerve*, and that a nerve should be insensible? But then, as the foundation of a great system, if I can but sustain them by repeated experiments, I am made; and a real gratification ensured for a large portion of my existence."

25th May, 1810.—"I was at the play last night, Mrs Siddons in Constance. I go on with my old plan—taking her Commentaries on Shakespeare and the Passions[1].

"Indeed, I turn me more and more again to the Anatomy of Expression; and the more, that I have lately had the most severe disappointments in my experiments on the nerves. Confident that I was to make a system captivating as the circulation, and possessed powerfully by this idea of a decided superiority, at one brave bound, you may imagine my disappointment.

"I weary to see you, and weary for the country. The eternal din! O, for that silence in which I could distinctly hear myself speak. Solitary confinement is preferable to this incessant motion. Now, too, the foliage is cool and dark; the light breaks through the

[1] See *Life of Mrs Siddons*, by Campbell.

trees with silvery splendour, and the distance is bright and enticing. Of this the Park informs me. I shall go to Lynn's[1] cottage; but there is such studied negligence, such flower-pot gardening, it cramps and confines one's every thought."

9th June, 1810.—"I continue to paint. And my Brain will hold together still.

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"I shall not forget to write to you of the paintings I occasionally see, but at this moment my mind is all agog about my Nervous System. It occupies me chiefly. Yet it is only in sitting ruminating, not in work."

About *Sept.* 1810.—"O! for time to write out my Brain. *It shall be good.* I won't publish though. Does this look like a man very unhappy?"

11*th Dec.* 1810.—"I should like to send my Brain (!) to the Edinburgh Society. It shall be my most pleasant work."

July, 1811.—"...But my serious study will be the small ornate account of the Anatomy of the Brain. On this I shall swell myself into importance, and make myself very happy..."

IDEA OF A NEW ANATOMY OF THE BRAIN; SUBMITTED *FOR THE OBSERVATIONS OF HIS FRIENDS.*

By CHARLES BELL, F.R.S.E.

NOTE.

THE want of any consistent history of the Brain and Nerves, and the dull unmeaning manner which is in use of demonstrating the brain, may authorize any novelty in the manner of treating the subject.

I have found some of my friends so mistaken in their conception of the object of the demonstrations which I have delivered in my lectures, that I wish to vindicate myself at all hazards. They would have it that I am in search of the seat of the soul; but I wish only to investigate the structure of the brain, as we examine the structure of the eye and ear.

It is not more presumptuous to follow the tracts of nervous matter in the brain, and to attempt to discover the course of sensation, than it is to trace the rays of light through the humours of the eye, and to say, that the retina is the seat of vision. Why are we to close the investigation with the discovery of the external organ?

[1] A distinguished Surgeon.

It would have been easy to have given this Essay an imposing splendour, by illustrations and engravings of the parts, but I submit it as a sketch to those who are well able to judge of it in this shape.

THE prevailing doctrine of the anatomical schools is, that the whole brain is a common sensorium; that the extremities of the nerves are organized, so that each is fitted to receive a peculiar impression; or that they are distinguished from each other only by delicacy of structure, and by a corresponding delicacy of sensation, that the nerve of the eye, for example, differs from the nerves of touch only in the degree of its sensibility.

It is imagined that impressions, thus differing in kind, are carried along the nerves to the sensorium, and presented to the mind; and that the mind, by the same nerves which receive sensation, sends out the mandate of the will to the moving parts of the body.

It is further imagined, that there is a set of nerves, called vital nerves, which are less strictly connected with the sensorium, or which have upon them knots, cutting off the course of sensation, and thereby excluding the vital motions from the government of the will.

This appears sufficiently simple and consistent, until we begin to examine anatomically the structure of the brain, and the course of the nerves,—then all is confusion: the divisions and subdivisions of the brain, the circuitous course of nerves, their intricate connections, their separation and re-union, are puzzling in the last degree, and are indeed considered as things inscrutable. Thus it is, that he who knows the parts the best, is most in a maze, and he who knows least of anatomy, sees least inconsistency in the commonly received opinion.

In opposition to these opinions, I have to offer reasons for believing, That the cerebrum and cerebellum are different in function as in form; That the parts of the cerebrum have different functions; and that the nerves which we trace in the body are not single nerves possessing various powers, but bundles of different nerves, whose filaments are united for the convenience of distribution, but which are distinct in office, as they are in origin from the brain:

That the external organs of the senses have the matter of the nerves adapted to receive certain impressions, while the corresponding organs of the brain are put in activity by the external excitement: That the idea or perception is according to the part of the brain to which the nerve is attached, and that each organ has a certain limited number of changes to be wrought upon it by the external impression:

That the nerves of sense, the nerves of motion, and the vital nerves, are distinct through their whole course, though they seem sometimes united in one bundle; and that they depend for their attributes on the organs of the brain to which they are severally attached.

The view which I have to present, will serve to show why there are divisions, and many distinct parts in the brain: why some nerves are simple in their origin and distribution, and others intricate beyond description. It will explain the apparently accidental connection between the twigs of nerves. It will do away the difficulty of conceiving how sensation and volition should be the operation of the same nerve at the same moment. It will show how a nerve may lose one property, and retain another; and it will give an interest to the labours of the anatomist in tracing the nerves.

IDEA &c.

WHEN in contemplating the structure of the eye we say, how admirably it is adapted to the laws of light! we use language which implies a partial, and consequently an erroneous view. And the philosopher takes not a more enlarged survey of nature when he declares how curiously the laws of light are adapted to the constitution of the eye.

This creation, of which we are a part, has not been formed in parts. The organ of vision, and the matter or influence carried to the organ, and the qualities of bodies with which we are acquainted through it, are parts of a system great beyond our imperfect comprehension, formed as it should seem at once in wisdom; not pieced together like the work of human ingenuity.

When this whole was created, (of which the remote planetary system, as well as our bodies, and the objects more familiar to our observation, are but parts), the mind was placed in a body not merely suited to its residence, but in circumstances to be moved by the materials around it; and the capacities of the mind, and the powers of the organs, which are as a medium betwixt the mind and the external world, have an original constitution framed in relation to the qualities of things.

It is admitted that neither bodies nor the images of bodies enter the brain. It is indeed impossible to believe that colour can be conveyed along a nerve; or the vibration in which we suppose sound to consist can be retained in the brain: but we can conceive, and have reason to believe, that an impression is made upon the organs of the outward senses when we see, or hear, or taste.

In this inquiry it is most essential to observe, that while each organ of sense is provided with a capacity of receiving certain changes to be played upon it, as it were, yet each is utterly incapable of receiving the impressions destined for another organ of sensation.

It is also very remarkable that an impression made on two different nerves of sense, though with the same instrument, will produce two distinct sensations; and the ideas resulting will only have relation to the organ affected.

As the announcing of these facts forms a natural introduction to the Anatomy of the Brain, which I am about to deliver, I shall state them more fully.

There are four kinds of Papillæ on the tongue, but with two of those only we have to do at present. Of these, the Papillæ of one kind form the seat of the sense of taste; the other Papillæ (more numerous and smaller) resemble the extremities of the nerves in the common skin, and are the organs of touch in the tongue. When I take a sharp steel point, and touch one of *these* Papillæ, I feel the sharpness. The sense of *touch* informs me of the shape of the instrument. When I touch a Papilla of taste, I have no sensation similar to the former. I do not know that a point touches the tongue, but I am sensible of a metallic taste, and the sensation passes backward on the tongue.

In the operation of couching the cataract, the pain of piercing the retina with a needle is not so great as that which proceeds from a grain of sand under the eyelid. And although the derangement of the stomach sometimes marks the injury of an organ so delicate, yet the pain is occasioned by piercing the outward coat, not by the affection of the expanded nerve of vision.

If the sensation of light were conveyed to us by the retina, the organ of vision, in consequence of that organ being as much more sensible than the surface of the body as the impression of light is more delicate than that pressure which gives us the sense of touch; what would be the feelings of a man subjected to an operation in which a needle were pushed through the nerve. Life could not bear so great a pain.

But there is an occurrence during this operation on the eye which will direct us to the truth: when the needle pierces the eye, the patient has the sensation of a spark of fire before the eye.

This fact is corroborated by experiments made on the eye. When the eye-ball is pressed on the side, we perceive various coloured light. Indeed the mere effect of a blow on the head might inform us, that sensation depends on the exercise of the organ affected, not on the impression conveyed to the external organ; for by the vibra-

tion caused by the blow, the ears ring, and the eye flashes light, while there is neither light nor sound present.

It may be said, that there is here no proof of the sensation being in the brain more than in the external organ of sense. But when the nerve of a stump is touched, the pain is as if in the amputated extremity. If it be still said that this is no proper example of a peculiar sense existing without its external organ, I offer the following example: Quando penis glandem exedat ulcus, et nihil nisi granulatio maneat, ad extremam tamen nervi pudicæ partem ubi terminatur sensus supersunt, et exquisitissima sensus gratificatio.

If light, pressure, galvanism, or electricity produce vision, we must conclude that the idea in the mind is the result of an action excited in the eye or in the brain, not of anything received, though caused by an impression from without. The operations of the mind are confined not by the limited nature of things created, but by the limited number of our organs of sense. By induction we know that things exist which yet are not brought under the operation of the senses. When we have never known the operation of one of the organs of the five senses, we can never know the ideas pertaining to that sense; and what would be the effect on our minds, even constituted as they now are, with a superadded organ of sense, no man can distinctly imagine.

As we are parts of the creation, so God has bound us to the material world by this law of our nature, that it shall require excitement from without, and an operation produced by the action of things external to rouse our faculties: But that once brought into activity, the organs can be put in exercise by the mind, and be made to minister to the memory and imagination, and all the faculties of the soul.

I shall hereafter shew, that the operations of the mind are seated in the great mass of the cerebrum, while the parts of the brain to which the nerves of sense tend, strictly form the seat of the sensation, being the internal organs of sense. These organs are operated upon in two directions. They receive the impression from without, as from the eye and ear: and as their action influences the operations of the brain producing perception, so are they brought into action and suffer changes similar to that which they experience from external pressure by the operation of the will; or, as I am now treating of the subject anatomically, by the operation of the great mass of the brain upon them.

In all regulated actions of the muscles we must acknowledge that they are influenced through the same nerves, by the same operation of the sensorium. Now the operations of the body are as nice and curious, and as perfectly regulated before Reason has sway, as they are at any time after, when the muscular frame might be supposed to be under the guidance of sense and reason. Instinctive motions are the operations of the same organs, the brain and nerves and muscles, which minister to reason and volition in our mature years. When the young of any animal turns to the nipple, directed by the sense of smelling, the same operations are performed, and through the same means, as afterwards when we make an effort to avoid what is noxious, or desire and move towards what is agreeable.

The operations of the brain may be said to be threefold: 1. The frame of the body is endowed with the characters of life, and the vital parts held together as one system through the operation of the brain and nerves; and the secret operations of the vital organs suffer the controul of the brain, though we are unconscious of the thousand delicate operations which are every instant going on in the body. 2. In the second place, the instinctive motions which precede the developement of the intellectual faculties are performed through the brain and nerves. 3. In the last place, the operation of the senses in rouzing the faculties of the mind, and the exercise of the mind over the moving parts of the body, is through the brain and nerves. The first of these is perfect in nature, and independent of the mind. The second is a prescribed and limited operation of the instrument of thought and agency. The last begins by imperceptible degrees, and has no limit in extent and variety. It is that to which all the rest is subservient, the end being the calling into activity and the sustaining of an intellectual being.

Thus we see that in as far as is necessary to the the great system, the operation of the brain, nerves, and muscles are perfect from the beginning; and we are naturally moved to ask, Might not the operations of the mind have been thus perfect and spontaneous from the beginning as well as slowly excited into action by outward impressions? Then man would have been an insulated being, not only cut off from the inanimate world around him, but from his fellows; he would have been an individual, not a part of a whole. That he may have a motive and a spring to action, and suffer pain and pleasure, and become an intelligent being, answerable for his actions,—sensa-

tion is made to result from external impression, and reason and passion to come from the experience of good and evil; first as they are in reference to his corporeal frame, and finally as they belong to the intellectual privations and enjoyments.

THE brain is a mass of soft matter, in part of a white colour, and generally striated; in part of a grey or cineritious colour having no fibrous appearance. It has grand divisions and subdivisions: and as the forms exist before the solid bone incloses the brain; and as the distinctions of parts are equally observable in animals whose brain is surrounded with fluid, they evidently are not accidental, but are a consequence of internal structure; or in other words they have a correspondence with distinctions in the uses of the parts of the brain.

On examining the grand divisions of the brain we are forced to admit that there are four brains. For the brain is divided longitudinally by a deep fissure; and the line of distinction can even be traced where the sides are united in substance. Whatever we observe on one side has a corresponding part on the other; and an exact resemblance and symmetry is preserved in all the lateral divisions of the brain. And so, if we take the proof of anatomy, we must admit that as the nerves are double, and the organs of sense double, so is the brain double; and every sensation conveyed to the brain is conveyed to the two lateral parts; and the operations performed must be done in both lateral portions at the same moment.

I speak of the lateral divisions of the brain being distinct brains combined in function, in order the more strongly to mark the distinction betwixt the anterior and posterior grand divisions. Betwixt the lateral parts there is a strict resemblance in form and substance: each principal part is united by transverse tracts of medullary matter; and there is every provision for their acting with perfect sympathy. On the contrary, the *cerebrum*, the anterior grand division, and the *cerebellum* the posterior grand division, have slight and indirect connection. In form and division of parts, and arrangement of white and grey matter, there is no resemblance. There is here nothing of that symmetry and correspondence of parts which is so remarkable betwixt the right and left portions.

I have found evidence that the vascular system of the cerebellum may be affected independently of the vessels of the cerebrum. I

have seen the whole surface of the cerebellum studded with spots of extravasated blood as small as pin heads, so as to be quite red, while no mark of disease was upon the surface of the cerebrum. The action of vessels it is needless to say is under the influence of the parts to which they go; and in this we have a proof of a distinct state of activity in the cerebrum and cerebellum.

From these facts, were there no others, we are entitled to conclude, that in the operations excited in the brain there cannot be such sympathy or corresponding movement in the cerebrum and cerebellum as there is betwixt the lateral portions of the cerebrum; that the anterior and posterior grand divisions of the brain perform distinct offices.

In examining this subject further, we find, when we compare the relative magnitude of the cerebrum to the other parts of the brain in man and in brutes, that in the latter the cerebrum is much smaller, having nothing of the relative magnitude and importance which in man it bears to the other parts of the nervous system; signifying that the cerebrum is the seat of those qualities of mind which distinguish man. We may observe also that the posterior grand division, or *cerebellum* remains more permanent in form: while the cerebrum changes in conformity to the organs of sense, or the endowments of the different classes of animals. In the inferior animals, for example, where there are two external organs of the same sense, there is to be found two distinct corresponding portions of cerebrum, while the cerebellum corresponds with the frame of the body.

In thinking of this subject, it is natural to expect that we should be able to put the matter to proof by experiment. But how is this to be accomplished, since any experiment direct upon the brain itself must be difficult, if not impossible?—I took this view of the subject. The *medulla spinalis* has a central division, and also a distinction into anterior and posterior fasciculi, corresponding with the anterior and posterior portions of the brain. Further we can trace down the crura of the *cerebrum* into the anterior fasciculus of the spinal marrow, and the crura of the *cerebellum* into the posterior fasciculus. I thought that here I might have an opportunity of touching the *cerebellum*, as it were, through the posterior portion of the spinal marrow, and the cerebrum by the anterior portion. To this end I made experiments which, though they were not conclusive, encouraged me in the view I had taken.

I found that injury done to the anterior portion of the spinal

marrow, convulsed the animal more certainly than injury done to the posterior portion; but I found it difficult to make the experiment without injuring both portions.

Next considering that the spinal nerves have a double root, and being of opinion that the properties of the nerves are derived from their connections with the parts of the brain, I thought that I had an opportunity of putting my opinion to the test of experiment, and of proving at the same time that nerves of different endowments were in the same cord, and held together by the same sheath.

On laying bare the roots of the spinal nerves, I found that I could cut across the posterior fasciculus of nerves, which took its origin from the posterior portion of the spinal marrow without convulsing the muscles of the back; but that on touching the anterior fasciculus with the point of the knife, the muscles of the back were immediately convulsed.

Such were my reasons for concluding that the cerebrum and the cerebellum were parts distinct in function, and that every nerve possessing a double function obtained that by having a double root. I now saw the meaning of the double connection of the nerves with the spinal marrow; and also the cause of that seeming intricacy in the connections of nerves throughout their course, which were not double at their origins.

The spinal nerves being double, and having their roots in the spinal marrow, of which a portion comes from the cerebrum and a portion from the cerebellum, they convey the attributes of both grand divisions of the brain to every part; and therefore the distribution of such nerves is simple, one nerve supplying its destined part. But the nerves which come directly from the brain, come from parts of the brain which vary in operation; and in order to bestow different qualities on the parts to which the nerves are distributed, two or more nerves must be united in their course or at their final destination. Hence it is that the 1st nerve must have branches of the 5th united with it: hence the *portio dura* of the 7th pervades everywhere the bones of the cranium to unite with the extended branches of the 5th: hence the union of the 3rd and 5th in the orbit: hence the 9th and 5th are both sent to the tongue: hence it is, in short, that no part is sufficiently supplied by one single nerve, unless that nerve be a nerve of the spinal marrow, and have a double root, a connection (however remotely) with both the cerebrum and cerebellum.

Such nerves as are single in their origin from the spinal marrow will be found either to unite in their course with some other nerve, or to be such as are acknowledged to be peculiar in their operation.

The 8th nerve is from the portion of the *medulla oblongata*[1] which belongs to the cerebellum: the 9th nerve comes from the portion which belongs to the cerebrum. The first is a nerve of the class called Vital nerves, controuling secretly the operation of the body; the last is the Motor nerve of the tongue, and is an instrument of volition. Now the connections formed by the 8th nerve in its course to the viscera are endless; it seems nowhere sufficient for the entire purpose of a nerve; for everywhere it is accompanied by others, and the 9th passes to the tongue, which is already profusely supplied by the 5th.

Understanding the origin of the nerves in the brain to be the source of their powers, we look upon the connections formed betwixt distant nerves, and upon the combination of nerves in their passage, with some interest; but without this the whole is an unmeaning tissue. Seeing the seeming irregularity in one subject, we say it is accident; but finding that the connections never vary, we say only that it is strange, until we come to understand the necessity of nerves being combined in order to bestow distinct qualities on the parts to which they are sent.

The *cerebellum* when compared with the *cerebrum* is simple in its form. It has no internal tubercles or masses of cineritious matter in it. The medullary matter comes down from the cineritious cortex, and forms the *crus;* and the *crus* runs into union with the same process from the cerebrum; and they together form the *medulla spinalis*, and are continued down into the spinal marrow; and these crura or processes afford double origin to the double nerves of the spine. The nerves proceeding from the Crus Cerebelli go everywhere (in seeming union with those from the Crus Cerebri); they unite the body together, and controul the actions of the bodily frame; and especially govern the operation of the viscera necessary to the continuance of life.

In all animals having a nervous system, the *cerebellum* is apparent, even though there be no *cerebrum.* The cerebrum is seen in such tribes of animals as have organs of sense, and it is seen to be

[1] The *medulla oblongata* is only the commencement of the spinal marrow.

near the eyes, or principal organ of sense; and sometimes it is quite separate from the *cerebellum.*

The cerebrum I consider as the grand organ by which the mind is united to the body. Into it all the nerves from the external organs of the senses enter; and from it all the nerves which are agents of the will pass out.

If this be not at once obvious, it proceeds only from the circumstance that the nerves take their origin from the different parts of the brain; and while those nerves are considered as simple cords, this circumstance stands opposed to the conclusion which otherways would be drawn. A nerve having several roots, implies that it propagates its sensation to the brain generally. But when we find that the several roots are distinct in their endowments, and are in respect to office distinct nerves; then the conclusion is unavoidable, that the portions of the brain are distinct organs of different functions.

To arrive at any understanding of the internal parts of the cerebrum, we must keep in view the relation of the nerves, and must class and distinguish the nerves, and follow them into its substance. If all ideas originate in the mind from external impulse, how can we better investigate the structure of the brain than by following the nerves, which are the means of communication betwixt the brain and the outward organs of the senses?

The nerves of sense, the olfactory, the optic, the auditory, and the gustatory nerve, are traced backwards into certain tubercles or convex bodies in the base of the brain. And I may say, that the nerves of sense either form tubercles before entering the brain, or they enter into those convexities in the base of the *cerebrum.* These convexities are the constituent parts of the cerebrum, and are in all animals necessary parts of the organs of sense: for as certainly as we discover an animal to have an external organ of sense, we find also a medullary tubercle; whilst the superiority of animals in intelligence is shown by the greater magnitude of the hemispheres or upper part of the cerebrum.

The convex bodies which are seated in the lower part of the cerebrum, and into which the nerves of sense enter, have extensive connection with the hemispheres on their upper part. From the medullary matter of the hemispheres, again, there pass down, converging to the crura, Striæ, which is the medullary matter taking upon it the character of a nerve; for from the Crura

Cerebri, or its prolongation in the anterior Fasciculi of the spinal marrow, go off the nerves of motion.

But with these nerves of motion which are passing outward there are nerves going inwards; nerves from the surfaces of the body; nerves of touch; and nerves of peculiar sensibility, having their seat in the body or viscera. It is not improbable that the tracts of cineritious matter which we observe in the course of the medullary matter of the brain, are the seat of such peculiar sensibilities; the organs of certain powers which seem resident in the body.

As we proceed further in the investigation of the function of the brain, the discussion becomes more hypothetical. But surely physiologists have been mistaken in supposing it necessary to prove sensibility in those parts of the brain which they are to suppose the seat of the intellectual operations. We are not to expect the same phenomena to result from the cutting or tearing of the brain as from the injury to the nerves. The function of the one is to transmit sensation; the other has a higher operation. The nature of the organs of sense is different; the sensibilities of the parts of the body are very various. If the needle piercing the retina during the operation of couching gives no remarkable pain, except in touching the common coats of the eye, ought we to imagine that the seat of the higher operations of the mind should, when injured, exhibit the same effects with the irritation of a nerve? So far therefore from thinking the parts of the brain which are insensible, to be parts inferior (as every part has its use), I should even from this be led to imagine that they had a higher office. And if there be certain parts of the brain which are insensible, and other parts which being injured shake the animal with convulsions exhibiting phenomena similar to those of a wounded nerve, it seems to follow that the latter parts which are endowed with sensibility like the nerves are similar to them in function and use; while the parts of the brain which possess no such sensibility are different in function and organization from the nerves, and have a distinct and higher operation to perform.

If in examining the apparent structure of the brain, we find a part consisting of white medullary Striæ and fasciculated like a nerve, we should conclude that as the use of a nerve is to transmit sensation, not to perform any more peculiar function, such tracts of matter are

media of communication, connecting the parts of the brain; rather than the brain itself performing the more peculiar functions. On the other hand, if masses are found in the brain unlike the matter of the nerve, and which yet occupy a place guarded as an organ of importance, we may presume that such parts have a use different from that of merely conveying sensation; we may rather look upon such parts as the seat of the higher powers.

Again, if those parts of the brain which are directly connected with the nerves, and which resemble them in structure, give pain when injured, and occasion convulsion to the animal as the nerves do when they are injured; and if on the contrary such parts as are more remote from the nerves, and of a different structure, produce no such effect when injured, we may conclude, that the office of the latter parts is more allied to the intellectual operations, less to mere sensation.

I have found at different times all the internal parts of the brain diseased without loss of sense; but I have never seen disease general on the surfaces of the hemispheres without derangement or oppression of the mind during the patient's life. In the case of derangement of mind, falling into lethargy and stupidity, I have constantly found the surface of the hemispheres dry and preternaturally firm, the membrane separating from it with unusual facility.

If I be correct in this view of the subject, then the experiments which have been made upon the brain tend to confirm the conclusions which I should be inclined to draw from strict anatomy; viz. that the cineritious and superficial parts of the brain are the seat of the intellectual functions. For it is found that the surface of the brain is totally insensible, but that the deep and medullary part being wounded the animal is convulsed and pained.

At first it is difficult to comprehend, how the part to which every sensation is referred, and by means of which we become acquainted with the various sensations, can itself be insensible; but the consideration of the wide difference of function betwixt a part destined to receive impressions, and a part which is the seat of intellect, reconciles us to the phenomenon. It would be rather strange to find, that there were no distinction exhibited in experiments on parts evidently so different in function as the organs of the senses, the nerves, and the brain. Whether there be a difference in the matter of the nervous system, or a distinction in organization, is of little importance to our enquiries, when it is proved that their essential

properties are different, though their union and co-operation be necessary to the completion of their function—the developement of the faculties by impulse from external matter.

All ideas originate in the brain: the operation producing them is the remote effect of an agitation or impression on the extremities of the nerves of sense; directly they are consequences of a change or operation in the proper organ of the sense which constitutes a part of the brain, and over these organs, once brought into action by external impulse, the mind has influence. It is provided, that the extremities of the nerves of the senses shall be susceptible each of certain qualities in matter; and betwixt the impression of the outward sense, as it may be called, and the exercise of the internal organ, there is established a connection by which the ideas excited have a permanent correspondence with the qualities of bodies which surround us.

From the cineritious matter, which is chiefly external, and forming the surface of the cerebrum; and from the grand center of medullary matter of the cerebrum, what are called the *crura* descend. These are fasciculated processes of the cerebrum, from which go off the nerves of motion, the nerves governing the muscular frame. Through the nerves of sense, the *sensorium* receives impressions, but the will is expressed through the medium of the nerves of motion. The secret operations of the bodily frame, and the connections which unite the parts of the body into a system, are through the cerebellum and nerves proceeding from it.

THE END[1].

The most distinguishing feature of the Essay—that which constitutes its originality, and justifies the title—"Idea of a New Anatomy

[1] The Essay by a singular oversight was brought out without a date, either on the title-page or elsewhere. Other means of ascertaining the date having failed, application was made to Messrs Spottiswoode, successors of the printers, for information; and the following letter was received. NEW STREET SQUARE, *Feb.* 27, 1829. SIR, I have at length discovered that 100 copies were printed of the "Idea of the Anatomy of the Brain," at the end of August, 1811. I remain, &c. THOS. C. SHAW. *To* Mr (A.) SHAW, *Soho-Square.*

The Essay was first noticed publicly in April 1822, by Mr John Shaw, when he referred to it in his Paper, read before the Medico-Chirurgical Society, entitled, "On Partial Paralysis." The date he then gave was 1809. The mistake probably arose from his recollection of having, in 1808, transcribed the Essay,

of the Brain," and which, it may be added, ought always to be kept in mind in estimating its value,—is the announcement in it of an entirely new principle of investigating the functions of the Nervous System.

The method of research formerly followed, was to take the nerves, as they might be found passing along any part of the body remote from the brain or spinal cord, say, in the upper or lower extremity, and cutting them across, to observe the effects. By such means, and noticing the phenomena attending wounds of nerves in accidents, physiologists were brought to conclude, that to every nerve belonged the double functions of bestowing motor power and sensation, with perhaps, other undefined properties. A certain number may have rejected the view: but they had no facts to bring against it; and they were obliged to put up with it. "Scholastici fingunt," says Sauvages, only twelve years before the principle enunciated in the Essay was conceived, "ad convulsiones explicandas, alios nervos esse tantum motorios, et sensus expertes: quod cum *millenis vivisectionibus* falsum evincatur admittendum non est: nulla enim in corpore est fibra nervea quin sentiat." (*Nosol. Method.*, Tom. III. p. 17, A.D. 1795.)

The "Idea," which formed both the title and theme of the Essay, seems at first view, quite simple; indeed, it bears on its face so much the semblance of truth, that it surprises us it should not have been thought of long before. It consists essentially in supposing,—that the divisions of the brain from which the various nerves proceed may have distinct endowments; and that the nerves connected with each division will partake the same endowments.

To prosecute the subject according to this theory, it is obvious that the mode of research must differ essentially from what had been followed before. Instead of going to the nerves in distant regions of the body, where they have contracted connections with others proceeding from many distinct parts,—the proper method will be to take the nerves near their origins in the brain and spinal cord, where they are perfectly simple in structure—where they are close, as it were, to the fountain head, and to make observations or experiments upon them there, at their roots. Through a knowledge of the functions of the roots of the nerves, it may be expected to

when it was in an early stage of preparation. See extract, 8th July, 1808. No competitor for the originality of the discoveries had appeared when his Paper was published.

learn what are the special endowments of the particular divisions of the Brain with which they are connected.

It was doubtless from being exalted with the thought that, in this new method of investigation, he had discovered a guide for penetrating into the arcana of the Brain, that the author expressed himself—with the confidence of one brother writing to another—in the sanguine tone of the Letters.

The Essay being professedly tentative, it is not fair to scan its contents too critically. Yet it will be allowed, even at this date, that the arguments in favour of the theory derived from the consideration of the essentially distinct nature of the impressions which are conveyed to the sensorium by each of the special nerves of the senses respectively, are full of interest in connection with the physiology of the brain.

The part of the Essay that will probably be read with chief interest, and canvassed with least favour, is the account at p. 14, of the experiments on the roots of the spinal nerves. In systematic works of physiology, principally foreign, it has become a custom, when treating of the originality of the discovery of the distinct functions of the nerves, to represent the experiments described in this Essay, as the only ones ever performed by the author,—to note their imperfections—and to assign to another physiologist the merit of having ascertained the true functions of the roots. An opportunity will occur before the close of this communication, to rectify this misconception. It is enough to say, at present, of the experiments related in the Essay, that the account is correct so far as it goes; that nothing is affirmed but what must have been actually observed. One positive statement alone is made, and it is this:—that on stimulating the anterior columns and roots, muscular contractions were excited: the remaining statement is negative—that on stimulating the posterior column and roots, no contraction of the muscles ensued. The accuracy of these observations cannot be questioned. And admitting their imperfections, the results were of essential service in confirming the theory: because they incontestably proved that the functions of nerves differ; and that the difference exists not only in the roots, but in the columns of the spinal cord with which the roots are connected.

By studying the context, and by that alone, it is made out that the author ascribed not only motor power (of which he had experimental evidence), but sensation (of which he had no experimental

evidence) to the anterior roots. Here, then, was a palpable and indisputable error. But when it is considered how that mistake arose—from mere general speculations on the endowments of the cerebrum as contrasted with the cerebellum, and defective knowledge of the true origins of the roots, a candid person will allow that it was not of a nature to cling to the author's mind with obstinate tenacity, or to be cast off with difficulty. In none of his published works can we discern any trace of the error[1].

But in ascribing both motor power and sensation to one set of roots, it may be thought that the author contravened the fundamental principle which it was the object of the Essay to propound. From the general tenour of the Essay, however, it cannot be doubted that the author conceived that the anterior roots consisted of two distinct sets of fibrils. At p. 8, he adverts to the unreasonableness of imagining, "that impressions thus differing in kind are carried along the nerves to the sensorium, and presented to the mind; and that the mind by the same nerves which receive sensation, sends out the mandate of the will to the moving parts of the body." Again, at p. 9, he anticipates as one of the results of the establishment of his views that they will "do away the difficulty of conceiving how sensation and volition should be the operation of the same nerve at the same moment."

The following are extracts from the Letters between the date of the circulation of the Essay and the publication of the author's paper read before the Royal Society.

29th Sept. 1811.—"My Idea of the Brain seems to be very well taken by all with whom I have conversed. Has anybody read it with you?"

(*About the same date as the above*).—"Has nobody seen my Brain? If I am not flattered, it takes here[2]."

[1] At a later period (1834) the author proved by dissection that the column of the spinal cord into which the posterior roots, those of sensation, enter—the lateral column—is continued up into the cerebrum; thus confirming his original idea, that sensation, in common with the other senses, has its seat in the cerebrum, not in the cerebellum.

[2] The following is copied from a list in Charles Bell's own handwriting, found in a journal, or common-place book, containing miscellaneous entries, the earliest of which is dated 1808. It is headed—"Names to whom copies of the Idea of the Anatomy of the Brain have been addressed."

Dr Renwick, Dr Brandreth [Liverpool], Dr Gartshore, Mr Leighton, Newc. [Newcastle], Mr Abernethy, Mr Pearson, Mr Lawrence [Sir Wm. Lawrence], Mr Wilson [Great Windmill Street School], Dr Maton, Dr Wollaston, Mr Young [Dr Thomas Young], Dr Mayo, Dr Sutherland, Portsmouth (3 copies), Dr Gartshore (4 copies), Lord Meadowbank [Scotch Judge], Dr Buchan, Dr Jeffray [Glasgow], Mr Playfair [Professor, Edinburgh], — Roscoe [Liverpool], Mr Ing-

22 *Nov.* 1811.—"Send one of my Brains to Sandford[1]. He entreated me once to write something on this subject to convert the young men at College: and if this answers his idea, he may take the credit to himself. If you can at any time pick up an opinion on this subject, note it for me. I wish to know people's opinion."

(*Same letter continued*).—"I gave an animated and good lecture to-day: I lectured on the Physiology of the Brain."

(*Same letter continued*).—"I went out yesterday with the intent of paying twelve guineas for one book! Gall, on the Brain; but luckily found there was no copy left in town."

Dec. 1811.—"I am now lecturing on the Nerves: and I see in this subject a great field for a man of genius and industry."

12*th Nov.* 1812 (*First Course of Lectures in Great Windmill Street*).—"I have been giving lectures on the Brain and Nerves, yesterday and to-day. Good, they say; certainly very different from what they have been accustomed to. I proceed gaining more interest in the subject of the nerves, &c."

10*th Nov.* 1813.—"I gave a lecture to-day, to a large class, upon the Brain. Yesterday, I gave one on the same subject, of an hour and three quarters, with only a green cloth before me. This will give you an idea of my improvement in talking."

10*th April*, 1814.—"Spurzheim gives us a lecture on Dr Gall. This will just suit me—give me the whole nonsense, and excite me."

30*th July*, 1814 (*To his wife, then in Scotland*).—"This morning after consulting with the surgeon of Tring about another gentleman, who had been thrown from the stage coach, I went off alone, distanced those I saw toiling after me, and had three delightful hours among the woods. Some ideas intruded into my mind that will make a very pleasing and consolatory conclusion to my views of the operations of the mind, vide 'Physiology of the Brain.' I also took a sketch."

19*th Nov.* 1814.—"I have been strangely engaged, without being able to say that I have been busy. To-day I finished my lectures on the Brain. My demonstration of the Brain brought a great concourse."

ham [Newcastle], Mr Horn [Newcastle], Mr Cooper [Sir Astley Cooper], Dr Dick [Madras Medical Service], Dr Winthrop, Mr Frampton, Dr Adams, Mr Davy [Sir H. Davy], Mr Brydon, Mr Baylie, Stowm^kt.^, Mr Allen [Holland House], Dr Baillie [Dr Matthew Baillie], Dr Gower, Dr Burrowe, Philadelph., Mr Knight (Taste) [author of Essay on Taste], Edinburgh (20 copies), Vose [Liverpool], Joberns [Middlesex Hospital], Cartwright [Middlesex Hospital], Smiles [Newcastle], Dr Pearson, Mr Thomson [Dr A. Tod Thomson], Dr Roget, Dr Curry [Guy's Hospital], Mr Chevalier, Young Cline [Henry Cline, Junior], Mr Park, Lpool., Dr Bostock, Jo. Brandreth, Dr Harness, Mr Brande, Soho Sq. [Chemist], F. Horner [Francis Horner, M.P.], Dr Gibson [America], Leo. Horner, Mr Rennell [Vicar of Kensington].

[1] Bishop of Edinburgh.

(*About same date as the above*).—"My Anatomy of the Brain is ripening in my head. In concluding my lectures on the Nervous System, I shall this year lay open a fine system."

2*nd Dec.* 1814.—"Wilson is lecturing just now, and I am chiefly employed about these nerves. I am making experiments through the galvanic apparatus, to try how far the action of nerves and muscles will agree with the division of nerves which I have made by dissection. The apparatus I use is very simple. I have a zinc probe and a silver probe; by placing them in contact with the nerve and the muscle, and bringing their ends together, the parts are convulsed. Now you know what I hope to prove is that there are two great classes of nerves, distinguishable in function—the one sensible, and the other insensible! I shall tell you of these experiments as I proceed."

Dec. 1815.—"To-day I finished my lectures on the Nervous System, on the Senses, and I can perceive that my more copious and earnest manner, and the notions I have got, become more and more attractive. I have been well attended, and left a full class to-day."

2 *March*, 1818.—"I wish to enter upon the Comparative anatomy of the Nervous System, which I can make a thing surprising."

5*th Aug.* 1819.—"When you left us, I told you I was to sit down to my notes on the Nervous System. Believe me this is quite an extraordinary business. I think the observations I have been able to make furnish the materials of a grand system, which is to revolutionize all we know of this part of Anatomy, more than the discovery of the Circulation of the Blood. I have a good deal still to do. How I am to bring it forward I do not know. I think my lectures in the first place: then by a little Essay explaining the outline of a new system; and finally by magnificent engravings of the whole Nervous System."

17*th August*, 1819.—"I continue to make little sketches of *cuddies* (Anglice, donkeys) the moment I get out of London. In the mean time, I am making gigantic drawings of the Nervous System for my class."

Feb. 1820.—"That over" (his annual lecture on Expression), we shall lecture humdrum for a fortnight, and then commence my System of Nerves, which is making as great a change as radicalism itself. But, dear George, we must keep these sentiments in our own breasts, there they mellow."

20*th March*, 1820.—"I have two noble subjects awaiting my leisure—a *Revolution* in Anatomy, and the subject of Expression—addressed to the better part of society."

14*th June*, 1820.—"My occupations are humdrumish. When I have time, I dissect the Nervous System of the lower animals: and I think I have made some observations which will ornament my sys-

tem and enrich my lectures. The only thing that interests me, and drags me to it, are my observations on the Nervous System. I have made some discoveries that must revolutionize this part of anatomy. But having succeeded, I find it dull work to prepare my observations in any way for the public. Lectures are pleasant and effectual, as far as they go. But the party of listeners is circumscribed: and others on whom the subject should be forced, stand squinting and jealous, and close their ears. You are a happy fellow to have such a good opinion of your profession."

22*nd September*, 1820.—"I have been so much taken up with finishing my illustrations of surgery—this MS. of John[1], and my experiments on the Nerves—that I am particularly deficient in preparation for my lectures this season, which will entail on me a season of discomfort."

March, 1821.—"This business of Nerves will be long of coming forward exactly as it should. But my own ambition has a rest in this—that I have made a greater discovery than ever was made by any one man in anatomy: and the best of it is I am not done yet."

April, 1821.—"I have just finished my Paper on the Nerves of the Face for the Royal Society. I put it into Jeffrey's hands this morning: but he is very busy....I do not know what he may think of it; he is no man of science[2]."

13*th July*, 1821.—"Last night my Paper was read before the Royal Society."

7*th Aug.* 1821.—"I think I told you my Paper was printing for the Royal Society: and I have been engaged yesterday and to-day in making a drawing for engraving in illustration of it."

30*th August*, 1821.—"My Paper is printing, and my drawing is under the engraver's hands, so that my lucubrations are in a fair way of being fairly before the public. John (Shaw) is off to Paris, and Richardson[3] comes to dine toe to toe to me."

The last series of extracts show that, during the ten years that intervened between the printing of the Essay, and the communication of his first Paper on the Nerves to the Royal Society, the author had not relaxed his efforts to advance the subject; on the contrary, many expressions point to his having then achieved, as he thought, several great successes. But before describing these, a word may be said about the reception which the Essay met with.

[1] John Bell's *Observations on Italy*.

[2] The paper eventually read to the Royal Society has the date 12th July, 1821. A rough copy, corrected by his own and other hands, is preserved, with the date 6th April. It is probably to the latter that the extract refers.

[3] A warmly cherished friend. See Notice of his Life, by the Lord Advocate Moncrieff, in the *North British Review*.

In the history of science, one may read of an example like this :—a man, of original genius, has had his mind illuminated by a bright insight of a comprehensive principle, pregnant with important results: from that moment, he will be afflicted with an aching dread lest some fellow labourer should hit upon the same idea, and by publishing anticipate him : not to be cut off from the expected honour of becoming a distinguished discoverer, what does the man of genius do? He forthwith writes out a declaration of the novel principle in cipher; seals the precious document, and locks it in the iron safe of a learned society, to be forthcoming when wanted. The author of the "Idea of a New Anatomy of the Brain," followed a course neither so ingenious, nor selfish. Yet he has stated that no competitor for the discoveries molested him, at that period, by trying to take them out of his hands. Of the distinguished anatomists and physiologists to whom copies were sent, not a single individual favoured him with observations, as solicited on the title page; far less showed any disposition to prosecute the enquiries independently.

Considering how critical was the position, as concerned his scientific reputation, in which the author had left the researches when he printed and circulated the Essay, it was fortunate that on returning to them, he should have found even a small fraction of the discoveries unappropriated and remaining to his share. Look for example, how closely he had approached to declaring the true functions of the roots of the spinal nerves, and yet how he had missed doing so. Is it not surprising that some clever man, or even intelligent pupil, did not detect the error in his interpretation of the experiments, and by presenting the correct one, secure high honour for his name?

But here a question of some moment—as to the value of experiments within the narrow area of the vertebral canal, meets us. It is quite a different thing proving to which root of the spinal nerves motor power belongs, from proving to which root sensation belongs by direct experiments. In the first, the evidence is indubitable. In the second, it is apt to be fallacious. When the spinal sheath is opened, and the anterior roots are taken hold of and pinched, there is instant contraction and quivering of the muscles subject to the nerves of the part; and the motion follows the stimulation so rapidly and constantly, that it is impossible to doubt the cause. The only way in which we can recognize the existence

of sensation, is by the animal's exhibiting, at particular manipulations, signs, interpreted as signs of pain. Yet these are but uncertain indications, and are frequently deceptive. What are they? They are cries, of different degrees of intensity; struggles of the limbs, more or less vigorous: mayhap, the use of the claws or teeth on the experimenter's fingers. Had the animal a mind, and articulate language, the evidence might perhaps be trustworthy: but as that mind would probably be clouded by the extensive wound in the back, together with the unavoidable concussion of the spine from the forcible breaking up of the vertebræ, doubts may be excusable on that head. At least, it will be admitted that the evidence as regards the root of sensation is not to be relied on with the same certainty, as that concerning the root of motion. And the remark is verified by the subsequent history of the enquiry. Soon after the promulgation of the discoveries, the experiments on the spinal nerves were often repeated. Those by M. Magendie became the most celebrated on account of their supposed exactness. In his first memoir he did give a correct view of the functions of each root, coinciding with that previously announced as held by the author. But in his second memoir, shortly following, he gave forth views directly at variance with those in the first. He alleged that sensation did not belong exclusively to either root. He asserted that the anterior root possessed sensation, as well as motor power; and he even assigned to the posterior roots a certain power of controlling the muscles. Out of these statements arose a grand controversy, prolonged into many years; the question being—on which of the roots, if on either, does sensation exclusively depend.

As none of the friends of the author complied with the invitation of the Essay, to be associated with the enquiries, he continued to prosecute them alone; eventually having the zealous assistance of his relative and early pupil, Mr John Shaw.

At this period, was conclusively solved the important problem of the distinction between the nerves of Motion and Sensation.

The mode in which that high feat in physiology was achieved may be briefly stated. It was mainly by observing with particular attention the differences in the anatomical characters of the roots of the cerebral nerves—comparing them with the nerves of the spine—and applying the principle of the researches announced in the Essay to the elucidation of their respective functions.

On taking a survey of the nerves of the encephalon with especial

regard to their *roots*, it is apparent that, in the majority, their distinguishing feature is, that they come off, unlike the spinal nerves, by single roots. Now according to the principle so often quoted, it might be inferred that these single-rooted nerves—as the Portio-dura, Third, Sixth, and Ninth, would be capable of conferring only one property. Next, the author observed that in the midst of those simple nerves, there was situated one of large dimensions, bearing resemblance to the spinal nerves in arising by two distinct roots; yet with the remarkable peculiarity—that the size of one root was about five times greater than that of the other. In accordance with the principle, it might therefore be inferred that this large double nerve, the Fifth, would possess double functions, each commensurate with the size of the respective roots.

Here, then, was a positive invitation for the author to institute experiments; first, upon one or more of the nerves which arise by single roots; secondly, on the nerve which arises by two roots, of unequal size.

In regard to the first, for facility of operating, he selected the Portio-dura. Near its exit from the stylo-mastoid foramen, he cut the nerve across in a living animal; and the result was so clear that it admitted of no question. The muscles of the face to which the Portio-dura is sent, were immediately paralysed. And that was the only effect. Sensation in the face was not in the slightest degree impaired. The proof therefore was complete, that the Portio-dura was exclusively a motor nerve.

The nerve which was next submitted to experiment, in contrast with the Portio-dura, was the Fifth: and the branches selected were those which, emerging upon the face, are distributed to parts also supplied by the Portio-dura. Upon each branch separately being cut across, in a living animal, sensation was instantly destroyed. Hence, no doubt could be entertained that these branches bestowed sensation on parts for which a different nerve was provided for giving motor power, namely, the Portio-dura. Here, then, was a decided proof that a nerve of motion may be distinct from a nerve of sensation.

But it has just been stated that owing to the Fifth nerve arising by two roots, it might be expected to possess double functions. Now here it must be admitted that the experimental proofs which the author brought forward in his first Paper to the Royal Society, to show that besides sensation, the nerve could bestow motor power,

failed. And as the history of the failure throws light on his mode of investigation, as contrasted with that of professed experimentalists, a few details in explanation may be pardoned.

One of the extracts (4th Dec. 1809) shows how averse the author was to making experiments. The only one by which he attempted to confirm the view—that the Fifth bestows motor power, in a limited degree, proportioned to the distribution of one of its roots, besides sensation generally, was made on the infraorbitary branches which supply the upper lip. And it cannot be doubted that he selected these branches, because he believed that part of both roots entered into their composition. But an anatomist of the present day does not require to be told that he was in error. However, before passing a severe judgment, the same anatomist ought to remember that, until a prominent interest in the anatomy of the roots of the nerves had been imparted by the author's own researches, a correct knowledge of the course and connections of those of the Fifth was not general. After carefully searching through all the standard books on Anatomy published in this country before the experiments in question were devised, I have not found a single work in which it is even stated that the Fifth arises by two roots. The author, accordingly, set about his experiments on the infraorbitary branches with the impression that he was about to show what would ensue from cutting across a nerve composed of fibrils coming from two distinct roots. And the results tallied in such a remarkable manner with what he had obviously looked for, that he concluded he had demonstrated the proposition accurately. When food was laid before the animal, an ass, it saw the oats, pressed its lips against the bowl containing them, and by moving the lips (through the Portio-dura) mumbled the oats, yet did not catch them, or convey them into the mouth. Witnessing these effects, the author interpreted them wrongly. He conceived that the muscles of the lips had been deprived of their power of acting in association with the muscles of mastication generally. He, therefore, supposed that he had proved experimentally the possession by the Fifth of motor power, in addition to sensation. And in his first published account of the nerve, he termed it the "nerve of sensation and mastication." No long time, however, elapsed before the error was observed. Two different physiologists, one abroad, and the other at home, drew attention to it. The former[1] merely said that he could not observe any

[1] M. Magendie: October, 1821.

defect of motion in the lips, produced by cutting the infraorbitary branch. The other[1] stated, in addition, what was certainly correct, that the circumstance of the ass being unable to direct food into its mouth, proved nothing more than that sensation had been destroyed: for if the animal could not feel the oats, it could not regulate the action of the lips so as to retain hold of them and pass them onward into the mouth. Thus it fell out that the only proof of an experimental kind on which the author relied for demonstrating that this double rooted nerve, the Fifth, besides sensation, could give motor power, was defeated. At the time the last physiologist referred to published his criticism, the author was absent from London, taking an annual holiday; and Mr John Shaw was the first to become acquainted with it. Being thoroughly master of the views for which the experiments had been instituted, he was aware of the jeopardy into which the discoveries were brought by the correction—when unaccompanied with any reference to the anatomical structure of the infraorbitary branches in relation to the roots: for neither of the two gentlemen who pointed out the error even alluded to the roots. He saw that, as all the experiments then made on the Fifth agreed in showing that it bestowed sensation only, the conclusion of all unprejudiced persons, and especially of all experimentalists, would be, that, albeit the nerve arose by double roots, it was simply a nerve of sensation. To counteract the injurious effect, he lost no time, therefore, in performing new experiments; which set the question at rest. Having procured an ass, he selected for his proceedings those branches of the third division of the Fifth, situated in the spheno-palatine fissure, where the two roots are conjoined. First, he cut both trunks across; whereupon the muscles which move the lower jaw were paralysed, and the teeth fell apart. After the animal had expired, the trunks were next pinched with forceps: I was at the time early in my pupilage, and assisted my brother in the experiment: having been instructed to keep the jaws separate, I was obeying when as soon as the forceps closed on the nerve, the teeth came together with a snap, and inflicted a smart bite on my fingers.

Thus no doubt could remain as to the view which the author originally gave of the functions of the Fifth being essentially correct. But it is evident that when he ascribed to it motor power and designated it the nerve of "sensation and *mastication*," he had no sound

[1] Mr Mayo: August, 1822.

experiment to prove that it conferred more than sensation. Hence the conclusion is unavoidable that he obtained a true insight of the functions of the nerve by reasoning and observation on the origin and distribution of the roots, guided by the fundamental principle of the researches—and not by experiment.

Next, let it be considered how directly the discovery of the functions of the nerves of the brain contributed to throw light on the functions of the roots of the spinal nerves. Taking, first, the Ninth nerve of the brain: the fact of its plunging into the muscles of the tongue, and going to them, to the exclusion of the surfaces, is sufficient proof that the name by which it was commonly known, Motor Linguæ, had been correctly applied,—that it is a nerve of motion, in contrast to a nerve of sensation: and when the anatomist looks to its origin at the top of the spinal cord, he cannot fail to recognize the perfect resemblance between its root and the anterior roots of the spinal nerves. Again, off the same tract from which the Ninth arises, there come in succession two other nerves that are undoubtedly motor; namely, the Sixth, and the Third. Passing to the Fifth; preceding anatomists had perceived the likeness it bears in the structure of its roots to the spinal nerves: when it had been shown, therefore, that the lesser root, which resembles the anterior spinal roots, in having no ganglion, bestows motor power alone; and that all the other known motor nerves (Portio-dura, Ninth, Sixth, Third) are devoid of ganglions, the conclusion was obvious, that the anterior roots of the spinal nerves give motor power. Further, when it was ascertained that the large root of the Fifth, on which a ganglion is formed, bestows sensation, the inference could be legitimately drawn, that the posterior roots of the spinal nerves which have ganglions, likewise confer sensation. It was while his mind was charged with those observations, that the author recurred to the experiments on the roots of the spinal nerves, described before in the Essay. And he performed them afresh. The results confirmed the truth of the deductions which he had been led to draw concerning the functions of each, from examining the anatomy and functions of the cerebral nerves. Ceasing to entertain the former view, that both motor power and sensation were united in one root, he saw that motor power alone belonged to the anterior, and that sensation belonged to the posterior roots.

But in addition to these experiments on the lower animals,

the author had valuable assistance in verifying his conclusions, from observing the effects of injuries or diseases of the nerves, in man. Thus many cases of affections of the Portio-dura presented themselves: and the same effects were observed in all: the muscles of the features lost their power: but the skin in the same parts retained sensation perfectly. Examples in the Fifth were more rare; but it was always found when those branches which emerge on the face were injured or diseased, that sensation was abolished, but the muscles preserved their power. The charge of publishing those cases fell to Mr John Shaw: in whose valuable paper, entitled on "Partial Paralysis[1]," besides the reports of cases illustrating local palsy from morbid affections of the nerves of the face, was contained the following pathological problem, and its solution:—"*Why sensation should remain entire in a limb when all voluntary power over the action of the muscles is lost; or why muscular power should remain when feeling is gone*[2]*?*" The answer, now so obvious as not to require repetition, was given correctly, and nearly as fully and satisfactorily as could be done at the present day.

It thus appears that, unaided by any but Mr John Shaw, the author had succeeded in discovering the great physiological truth,—that the nerves of Motion are distinct from the nerves of Sensation. Furthermore, he had specified those particular roots, or nerves, of the brain, and of the spinal cord, to which Motor power, or Sensation respectively belonged.

But before the author presented those observations formally to the public, or did more than lecture upon them, he had conceived a theory, upon the basis of which he had also constructed a general Classification of the nerves.

The starting-point of this theory was, from observing the remarkable anomalies which are exhibited in the distribution of the Fifth nerve, and the Portio-dura. The Fifth nerve alone of all the nerves of the brain, had been ascertained to resemble the spinal nerves. Like them it arises by two roots, one being a motor, the other a sensitive root. But a striking dissimilarity exists between it and the spinal nerves, in the relative size of their roots. In all the spinal nerves, the two roots are approximately equal; but in the Fifth, the root which bestows motor power is only about one-fifth

[1] Read to the Medico-Chirurgical Society, April 30, 1822.
[2] Italics in the original.

the size of the root which bestows sensation. Furthermore—and this is a point of special interest as regards the theory—the only muscles in the head over which the Fifth has power, are the group which perform the actions of *mastication.* Turning next to the Portio-dura, this had been ascertained to be a motor nerve. Yet it was observed, that it was allotted to one particular set of muscles of the head. In a part of its course, the nerve lies close to the muscles of the jaws, but it does not give even a single small twig to one of them; several of its large branches are spread upon the temporal and masseter muscles, but they skip these muscles entirely; and they squander themselves on a thoroughly different set, the muscles of the *features.*

Here, then, looking from this stand-point alone, the question is suggested, Why should there be that appointment of distinct motor nerves to distinct groups or classes of muscles, which are situated so near each other that it might be thought one would serve?

The author endeavoured to solve this problem as follows. He first took a general survey of the members of the body which are placed under the charge of the large series of spinal nerves, together with the Fifth, their representative in the head. It then occurred to him that those members were; first, the *locomotive* organs,—or in man, the inferior extremities: secondly, the *prehensile* organs,—or, in man, the superior extremities: and thirdly, the *masticatory* organs,—or, in man, the apparatus of jaws. In the next place, he took a general view of the *features*, the motions of which are presided over by the Portio-dura. It then occurred to him that the parts of the face so called, being chiefly connected with the lips and nostrils, are particularly connected with the organ of respiration, as that organ is framed in *man*, in contrast with the lower animals.

Reverting to the first series, he thought that the members embraced in it were required in all animals, even the lowest in structure. But to comprehend the nature, or number, of such members, the question must be asked—What are the broad and main distinctions between vegetablism and animalism? The predominant character of a vegetable, is that, having all essential organs for sustaining life, it is comparatively *motionless;* it is fixed to the ground, and being supplied with nourishment through its roots, it need not shift its quarters. But the leading character of an animal is, that being, like the vegetable, endowed with the necessary organs for sustaining life, it is *vagabond;* to obtain food for preserving life, it must

go forth to forage. Hence the necessity in the animal of a nervous system, for sense and motion. And in order to enable the animal to move and change its hunting ground, it must have *locomotive* organs; to enable it to seize and secure its food, it must have *prehensile* instruments; and, lastly, to enable it to reduce the food to a fit state for passing along the gullet, it must have grinding or *masticatory* organs. And so it may be seen that the most originally bestowed gifts to an animal, are those very members over which the spinal nerves, and Fifth, in man, exercise control. From arguments such as these the author designated that class, the "Original system."

Again, as to the muscles of the features, subject to the Portio-dura, what did the author mean by connecting them with the organ of respiration, as presented in *man?* The qualifying expression implies that the organ of respiration developed in man, possesses an exalted character which places it above the same organ in the lower animals. It is to be regretted that a fitter term for the class of nerves in which the Portio-dura was included could not be found than *respiratory:* for this reason, that the organ of breathing, particularly in man, performs two sets of offices, very different in character from each other. In the lowest animals, it has only one function, that of purifying the blood: in man, it continues to purify the blood; but at the same time it becomes, in connection with his Mind, the instrument of Voice, Speech, and Expression.

The changes in the structure of the organ of respiration throughout the animal kingdom are, indeed, manifold and vast. At first, the apparatus differs little from what is found in plants; it is situated on the exterior of the body, without provision, of course, for the air being collected, or expelled, to produce sound. By degrees, the purifying of the blood is effected by air being introduced into the interior, and permeating tubes, or even entering sacs: but communication is not yet established with a single outlet, or windpipe, to allow sound to be produced. In no member of the great division of Invertebrata does the air of respiration either enter, or escape, by the mouth. The first discernible trace of a tube, like windpipe, or of a sac, like lungs, is met with in the lowest of the Vertebrata, fishes: in them, for the first time, the mouth becomes a common orifice for food and breath. In all the subsequent acts of building up the organ to make it available for the double purposes of purifying the blood, and propelling the air outwardly with force, to produce sonorous vibrations, what are chiefly observed, are increased

compactness in the walls of the chest, and provisions in the windpipe for greater concentration, within narrow straits, of the volumes of expired air. But these adaptations for Voice affect not only the structures engaged in deglutition, but the circulation of the blood, chiefly the venous. And thus it may be perceived that, to meet these new exigencies, modifications in the arrangements of the nerves and brain-centres must be introduced. To that class of nerves, including the Portio-dura, the author applied the name "Superadded," in reference to the "Original System:" or "Respiratory," from their connection with the organ of respiration.

Adding the special nerves of the senses, and the nerves of the appendages of these organs, to the "Original" class, these and the "Respiratory" together, embrace the whole nerves of the cerebro-spinal axis. There remain the "Sympathetic" nerves. These ganglionic nerves were supposed to preside over the organic processes in the economy; such as nutrition, growth, reproduction, secretion, absorption, &c. which are common to vegetable and animal life: and they were classed separately. In the extract of 17th August, 1819, the author says that he was preparing "gigantic drawings of the nervous system for his class." These were three diagrams, on elephant-paper: one representing the "Original;" another the "Respiratory;" and the last, the "Sympathetic" system.

ALEXANDER SHAW.